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AGRICULTURAL MEMORANDUM NO. 848

To Verify the Method of Using Monthly Mean Maximum and Minimum Temperatures in the Calculation of Ontario Units

The "Ontario Unit" system assumes that plant development varies parabolically with air temperature above some base at which development is zero.

The Ontario Unit consists of a day and a night term.

Day term $Y = 3.33(TMAX - 10) - 0.084\ (TMAX - 10)^2$

Night term $X = 1.8(TMIN - 4.4)$.

TMAX is the day maximum air temperature ^{o}C
TMIN is the day minimum air temperature ^{o}C.

The day and night terms have bases of $10^{o}C$ and $4.4^{o}C$ respectively.

The Ontario Unit, $OU = (Y + X)/2$

A time consuming method of calculating Ontario Units involves using daily maximum and minimum temperatures in the above formulae and summing daily contributions for the month. Monthly mean maximum and minimum temperatures can also be used to find Y and X with the monthly OU totals obtained by multiplying the result of $(Y + X)/2$ by the number of days in the month.

To determine the accuracy of the latter method, twenty one stations, widely spaced throughout the UK, were chosen for which OU (daily) values (ie Ontario Units calculated using daily temperatures) had already been obtained.

The stations considered were:

Roscombe Down
Burlingham (May 59'-October 72')/Lowestoft (May74' October 74')
East Malling
Aberporth
Finingley
Ronaldsway
Shawbury
Skegness
Southport
Aldergrove
Valley
Elmdon
Exeter
Preston Wynne
Sutton Bonnington

Thorney Island
Cardiff - Penylan (May 59'-Oct 73')/Long Ashton (May 74'-Oct 74')
Turnhouse
Leuchars
Renfrew (May 59'-Oct 73')/Abbotsinch (May 67'-Oct 74')
Kinloss

Ontario Units were calculated for the months May to October for 1959, 1964, 1967, 1970, 1972, 1974 and for May and October of the intermediate years after it was found, from the years already considered, that the largest errors occurred during these two months. Years with exceptional temperature conditions were included so that any noticeable effects on the accuracy of the method could be distinguished eg during October 1974 the mean temperatures throughout the UK varied from 1.5 to 4.0 °C below average and was the coldest October in England and Wales as a whole since 1917, and in Scotland since 1926. The OU (monthly) value (ie Ontario Units calculated using monthly mean maximum and minimum temperatures) for each station were then compared with the correspondong OU(daily) figure, and the "% difference" then determined.

$$\% \text{ difference} = \frac{\text{OU (monthly)} - \text{OU (daily)}}{\text{OU (daily)}} \times 100\%$$

$$\text{OU (daily)} = \frac{\text{OU (monthly)}}{\left(\frac{\% \text{ difference}}{100} + 1\right)}$$

Table showing the percentage of occasions for the individual months over the whole period when the percentage differences were within the limits shown

	$-1\% \leq 1\%$	$-2\% \leq 2\%$	$-3\% \leq 3\%$	$-5\% \leq 5\%$
May	27.2	50.8	69.3	85.1
June	24.0	57.6	91.2	100.0
July	36.8	80.8	96.8	99.0
August	39.2	84.8	96.0	100.0
September	43.7	84.1	92.1	96.8
October	25.2	40.1	50.6	63.2

Table showing the fraction of occasions over the whole period when the percentage difference for selected stations were within the limits shown

	$-1\% \leq 1\%$	$-2\% \leq 2\%$	$-3\% \leq 3\%$	$-5\% \leq 5\%$
Boscombe Down	0.286	0.607	0.786	0.893
Aberporth	0.375	0.679	0.821	0.946
Southport	0.357	0.625	0.714	0.893
Valley	0.357	0.661	0.839	0.982
Preston Wynne	0.286	0.464	0.625	0.732
Turnhouse	0.268	0.464	0.571	0.679
Leuchars	0.250	0.464	0.571	0.661
Renfrew	0.232	0.357	0.571	0.643
Thorney Island	0.446	0.768	0.929	0.964
Exeter	0.446	0.786	0.893	0.946
Skegness	0.315	0.667	0.833	0.926
Burlingham	0.311	0.689	0.844	0.978

The largest percentage difference of all was -78.5% for Kinloss during October 1974.

Obviously such errors are unacceptably large. A graph was plotted to determine the correction factors which would give more realistic results. Monthly mean temperature was plotted against percentage difference for the months of May and October for all twenty one stations for the period 1959-74. From the graph it was possible to determine the required correction factor for a wide range of mean temperatures.

Monthly Mean Temperature °C	$\frac{\%\text{ difference} + 11}{100}$
7.3	0.2200
7.4	0.3300
7.5	0.4300
7.6	0.5000
7.7	0.5500
7.8	0.5800
7.9	0.6100
8.0	0.6400
8.1	0.6650
8.2	0.6950
8.3	0.7150
8.4	0.7400
8.5	0.7650
8.6	0.7850
8.7	0.8050
8.8	0.8250
8.9	0.8400
9.0	0.8550
9.1	0.8725
9.2	0.8825
9.3	0.8950
9.4	0.9050
9.5	0.9125
9.6	0.9250
9.7	0.9275
9.8	0.9350
9.9	0.9425
10.0	0.9490
10.1	0.9550
10.2	0.9600
10.3	0.9660
10.4	0.9700
10.5	0.9750
10.6	0.9800
10.7	0.9850
10.8	0.9875
10.9	0.9925
11.0	0.9950
11.1	0.9970
11.2	1.0000

For monthly mean temperatures above 11.2°C the OU (monthly) figure alone is used since in over 80% of the cases considered the average percentage difference (ie of all twenty one stations in any one month) was between -3% and 3%. The method is most accurate for monthly mean temperatures above 8°C with large inaccuracies occurring below 7.7°C.

Examples

1. Boscombe Down during September 1972:

OU (daily) = 359.1
Monthly mean maximum temperature = 16.5
Monthly mean minimum temperature = 7.7
Monthly mean temperature = 12.1

Using the formulae given:

Day term $Y = 3.33(16.5 - 10) - 0.084\ (16.5 - 10)^2$
$Y = 18.1$

Night term $X = 1.8\ (7.7 - 4.4)$
$X = 5.9$

$$\text{OU (monthly)} = \left(\frac{18.1 + 5.9}{2}\right) \times 30$$
$$= 360.0$$

2. Long Ashton during October 1974

OU (daily) = 112.3

Monthly mean maximum temperature = 11.3
Monthly mean minimum temperature = 5.1
Monthly mean temperature = 8.2

Day term $Y = 3.33(11.3 - 10) - 0.084\ (11.3 - 10)^2$
$Y = 4.2$

Night term $X = 1.8(5.1 - 4.4)$
$X = 1.26$

$$\text{OU (monthly)} = \frac{\left(\frac{4.2 + 1.26}{2}\right) \times 31}{0.6950}$$
$$= 122.7$$

Any comments or suggestions on this paper should be referred to the author.

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